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TITLE: REMOTE EXAMINATION OF SHROUD TUBES IN LMFBR FUEL ELEMENTS

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REMOTE EXAMINATION OF SHROUD TUBES
IN LMFBR FUEL ELEMENTS

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REMOTE EXAMINATION OF SHROUD TUBES

ABSTRACT

A system for providing a means of remote ejection and examination of sodium bonded shroud encapsulated fuels has been in use at LASL for over a year. The system is remotely capable of precise machining for clad separation and splitting at specified areas. Controlled heating and constant temperature monitoring is incorporated for sodium melting.

The system provides for numerous operations such as: visual examinations, measurements, photography, and sodium dissolution.

Irradiation testing of sodium-bonded carbide and nitride fuels indicated that cladding failure was possibly caused by the fuel cracking, rearrangement, and the mechanical wedging of the broken pieces inside the cladding. A practical solution was a device placed in the annular gap between the fuel and the cladding that prevented the broken fuel from rearranging and preventing a mechanical load on the cladding. A perforated, tubular restraint, called a shroud tube[1], shown in Fig. I, was selected for two reasons. The first being the simplicity during assembly and secondly it was calculated to have the best chance of success during operation.

The fabricated tubes for initial tests were made from various materials such as iron, tantalum, vanadium, and stainless steel with a wall thickness of 0.05 mm (.0020 inches) to 0.08 mm (.0031 inches); but in later tests the shroud tubes were of the same material as the cladding, type 316 stainless steel.

Following reactor tests of the advanced fuel pins, new techniques for the postmortem destructive examinations were required. To obtain meaningful data of shroud tube performance, it was necessary to eject the fragile tube and fuel, intact from the pin cladding with little or no distortion. Due to the possibility of pin bowing during irradiation, it was determined that a maxium length of 21 cm (8 inches) of shroud and fuel could be ejected successfully. The location for performing these examinations was within an inert alpha containment box with size limitation and gross alpha contamination. To meet dimensional and environmental restrictions in the existing facility, tooling and fixtures had to be designed under the following criteria.

1. Compactability: The device, shown in Fig. II, had to maintain dimensional requirements to be compatible with transfer parts in existing alpha boxes. After primary insertion of the assembled device into an alpha box by a 46 cm (18 in.) transfer

system, all components had to be sized for removal through smaller and more practical transfer ports for disposal or repair. Namely, the 18 cm (7 in.) port and the alpha tube transfer system.

2. Simplicity: Totally remote operation involved complex techniques to ensure accurate and reliable performance while minimizing malfunctions and incorporating simple operational techniques.
3. Performance requirements: The device was constructed by modifying a Unimat lathe (model DP-200) with design features needed to remove the shroud and fuel intact. It was necessary to restrain, without distortion, sections of fuel pins of varying lengths and diameters. The collet and chuck assembly of the DP-200 lathe met these requirements. The standard length of the lathe, 43 cm (17 in.), had to be extended by 29 cm (11.5 in.) to an overall length of 72 cm (28.5 in.) to accommodate the 41 cm (16 in.) length of a 20 cm (8 in.) ejected shroud tube.

The belt drive pulley system had to be redesigned completely to allow for extremely slow chuck speeds that were necessary for separation of the stainless steel cladding without the aid of cutting oil. The revised drive mechanism was required because of the enability of the Unimat A.C. motor to be Variac controlled and still maintain torque. Standard graphite motor brushes were replaced by stackpole brushes for operation in inert atmospheres. Electrical wiring and components were replaced by materials being of higher resistance to gamma radiation and adaptable to existing cell power supplies.

The heater assembly, shown in Fig. II, was designed to maintain a constant controlled temperature of 110°C evenly dispersed throughout the entire unit. Adequate heating was utilized by the use of two, 120 VAC, 250 watt flat bar heaters. Temperatures were monitored constantly on a Doric (model DS-350) digital thermocouple indicator by a copper constantan thermocouple located approximately at the center of the heater assembly. The two hinged and clamping sections of the heater assembly serves as the movable force for removing the outer clad from the shroud tube and the fuel. The tailstock assembly, shown in Fig. II, had to be designed to exert a constant center load on the fuel and shroud by the use of a threaded and adjustable rod that passed through the center of the tailstock. The pulling force was accomplished by manually rotating a thumbwheel and drawing the heater assembly containing the pin clad toward the tailstock. The pulling force on the pin clad and the heater assembly is approximately 22 Kg (10 lbs.) and is visually monitored by a calibrated spring loaded attachment coupled between the heater and tail-stock assemblies.

During ejection, the shroud tube and fuel (see Fig. III) is extruded onto the receiving surface, which allows the shroud tube to maintain an even plane with the external cladding to minimize binding and possible breaking of the brittle shroud material.

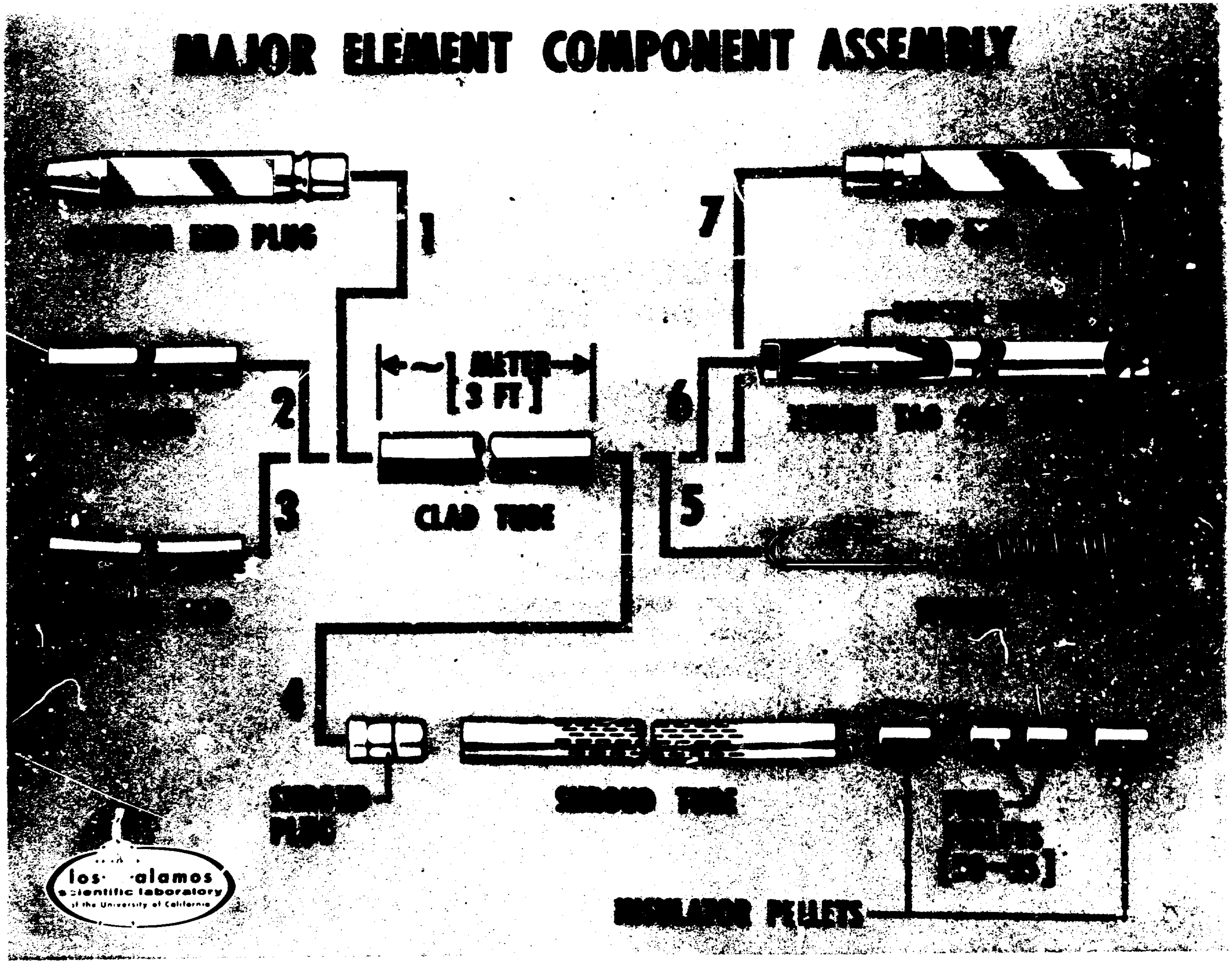
After ejection, the specimen is transferred to a special receiving tray, shown in Fig. IV, for visual inspection, photography, diameter measurements, sodium dissolution baths, and additional sectioning. A variety of remote hand held tools is required for the numerous examinations after the shroud has been ejected.

Several successful destructive disassemblies of shroud encapsulated fuel pins with 8.5 at. percent burnup at 70 and 90 Kw/m have been completed. Operational experience has shown the versatility of the prototype device to be a valuable asset for data acquisition in the examination of fast breeder advanced fuels.

REFERENCE

1. J. F. Kerrisk, J. O. Barner, and R. L. Petty, "Design and Performance of Shroud Tubes in Sodium-Bonded Advanced Fuel Elements," Proceedings of the Topical Meeting on Advanced LMFBR Fuels, J. Leary and H. Kittle (ed.), Tucson, Arizona, October 10-13, 1977, pp. 648-659.

FIGURES


MAJOR ELEMENT COMPONENT ASSEMBLY
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CLAD TUBE
SHROUD TUBE
INSULATOR PELLETS
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Fig. 1.

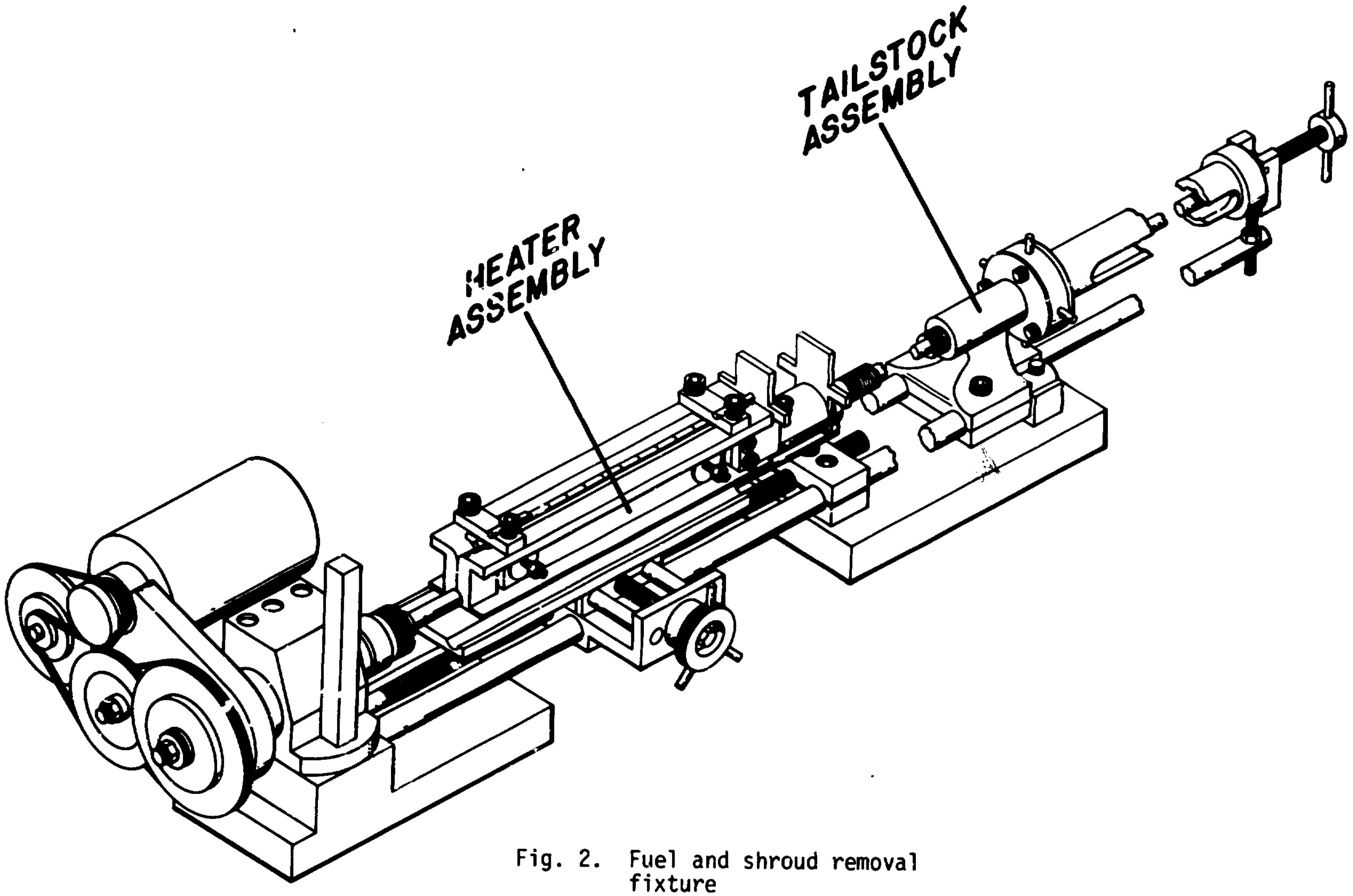

Fig. 2. Fuel and shroud removal fixture

Fig. 3. Typcial shroud encapsulated fuel

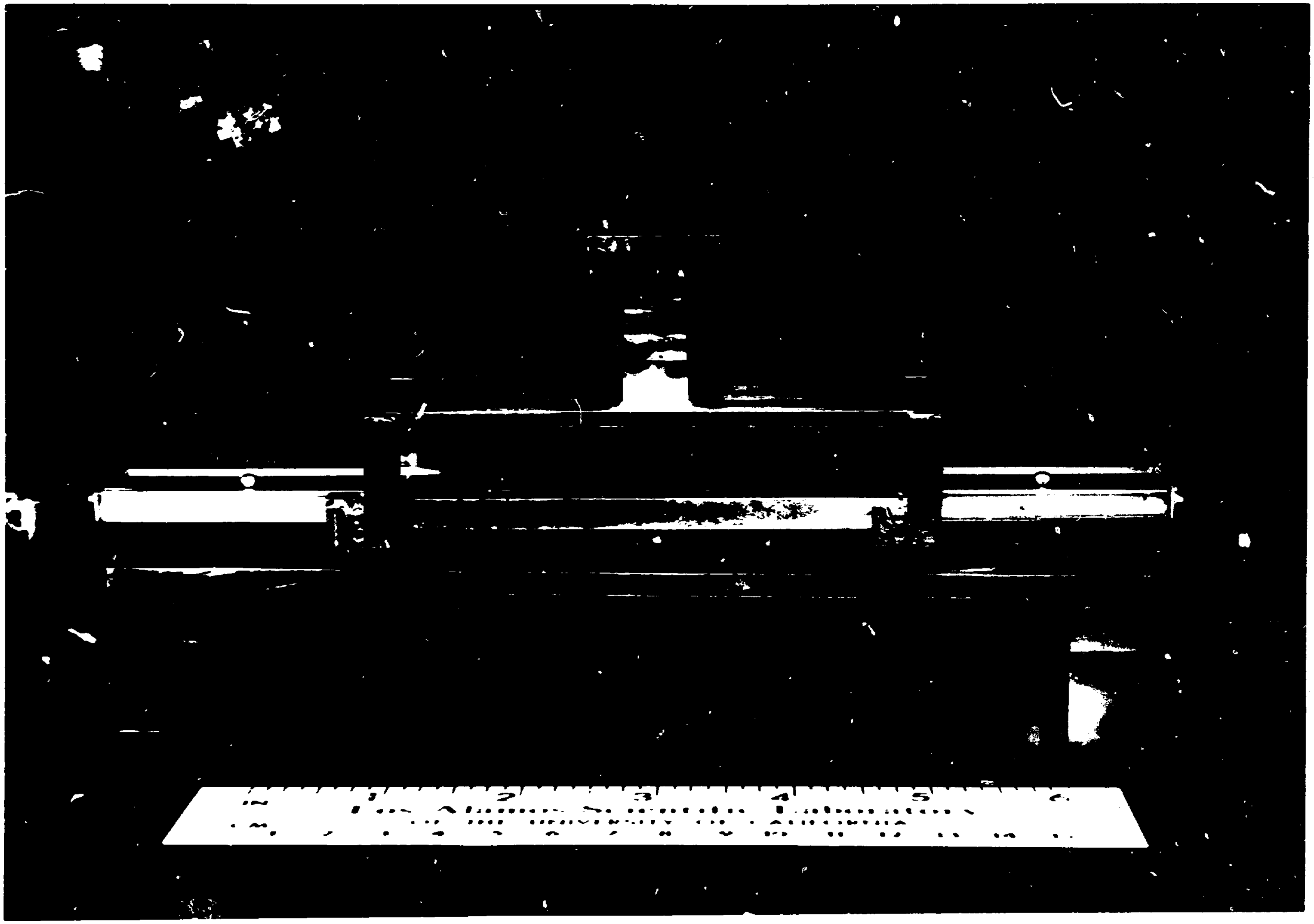

Fig. 4. Shroud receiving tray
and fixtures